



NATIONAL CENTER FOR
APPROPRIATE TECHNOLOGY

Massachusetts Urban Agriculture Conference

Greenhouse Design and Management

Presenter Chris Lent
NCAT Agricultural Specialist



NATIONAL CENTER FOR
APPROPRIATE TECHNOLOGY

**Helping People by championing small-scale,
local, and sustainable solutions to reduce
poverty, promote healthy communities, and
protect natural resources.**

<http://www.ncat.org>



ATTRA provides technical support on sustainable agriculture and farm energy.

- <http://www.attra.org>
- Toll Free 800-346-9140
- > 400 Publications
- Workshops/Conferences

What Is Sustainable Agriculture?

Master Publication List

Education

Energy Alternatives

Beginning Farmer

Field Crops

Horticultural Crops

Livestock & Pasture

Local Food Systems

Marketing, Business & Risk Management

Organic Farming

Pest Management

Soils & Compost

Water Management

Other Resources

"Armed To Farm" is Sustainable Agriculture Training For Military Veterans

NCAT has partnered with the USDA Agricultural Research Service, Farmer Veteran Coalition, University of Arkansas, Growing Warriors, and other sustainable agriculture organizations to train veterans interested in sustainable agriculture careers.

[» Learn More](#)

Helpful Links

♦ Sustainable Ag Webinars	♦ Organic Livestock Feed Suppliers	♦ Sustainable Producer Spotlight
♦ Upcoming Workshops	♦ Disaster Assistance	♦ Ecological Pest Management
♦ Organic Seed Suppliers	♦ ATTRA Newsletters	♦ Cosecha Mensual
	♦ Drought Programs and Resources	(Spanish-language e-newsletter)

Ask An Ag Expert

Use this online form to submit sustainable agriculture related questions to our Specialists.

Internship Opportunities

Sustainable Farming Internships & Apprenticeships

A directory of on-the-job learning opportunities.

News **Calendar** **Funding**

- ♦ Israeli Research Shows Encouraging Birds of Prey Reduces Rodenticide Use ~ 01/20/15
- ♦ California Strawberry Growers Consider Methyl Bromide Alternatives ~ 01/20/15
- ♦ Federal Court Rules Manure Can Be Regulated as Solid Waste ~ 01/20/15
- ♦ Report Details Opportunities For Agricultural Businesses To Grow Northeast Regional Economies ~ 01/19/15
- ♦ More Breaking News...

Lent's Organics



Photo: Chris Lent, NCAT

A greenhouse is a building with transparent walls and roof where the temperature and humidity can be controlled for the cultivation of plants.

A permanent structure made of glass, plastic, or fiberglass in which plants are cultivated year round under controlled temperature and humidity settings

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Zoning and Permits

- Boston Redevelopment Authority (BRA)
 - Article 89 (zoning code)
- Comprehensive Farm Review (CFR)
 - Residential
 - Small scale commercial
- Apply for permits (water, electrical, composting)
- **Building Permit**
- Use of Premises and Business Permits

Article 89 Made Easy:

Urban Agriculture Zoning For The City of Boston



Greenhouse Zoning

Ground Level Farms

- Height limits
 - Per zone
- Set back requirements
 - 5 feet

Rooftop Farms

- 25 ft. height limit
- Setbacks determined by building/safety and fire codes

Urban Agriculture in Boston: Permits and Approvals
Needed to Start Your Less Than One Acre Farm

Greenhouse Structures

Detached



Attached



Photo: Chris Lent, NCAT



Attached

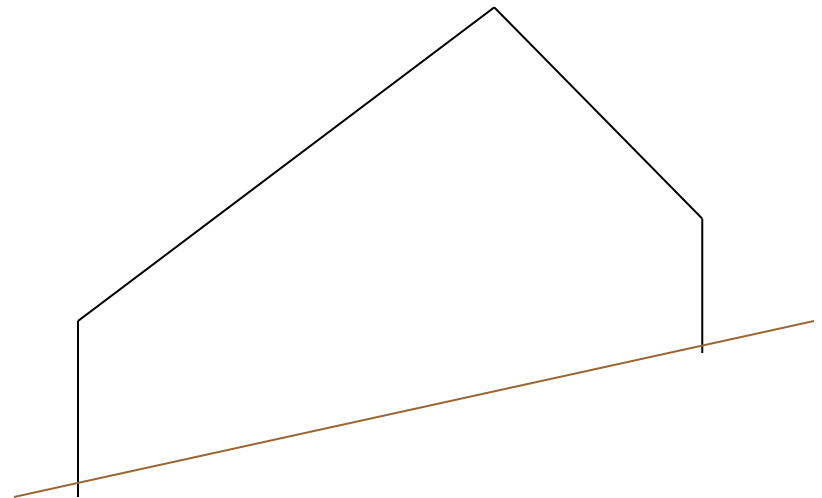
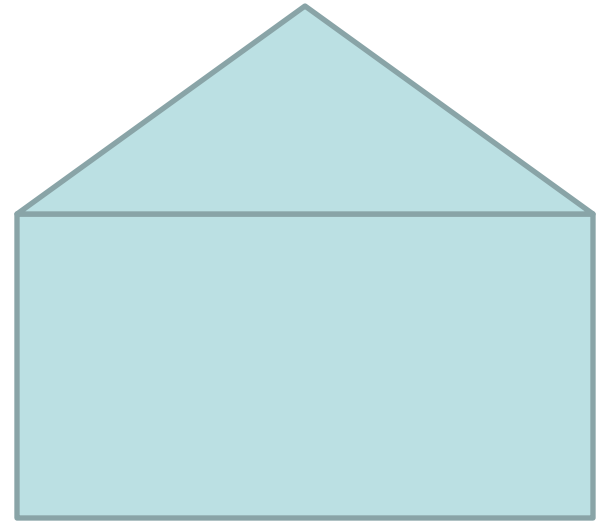


- Lean-to
- Ridge and Furrow
- Barrel Vault



Detached

- Even-span
- Uneven-span
- Quonset/Gothic



Gothic



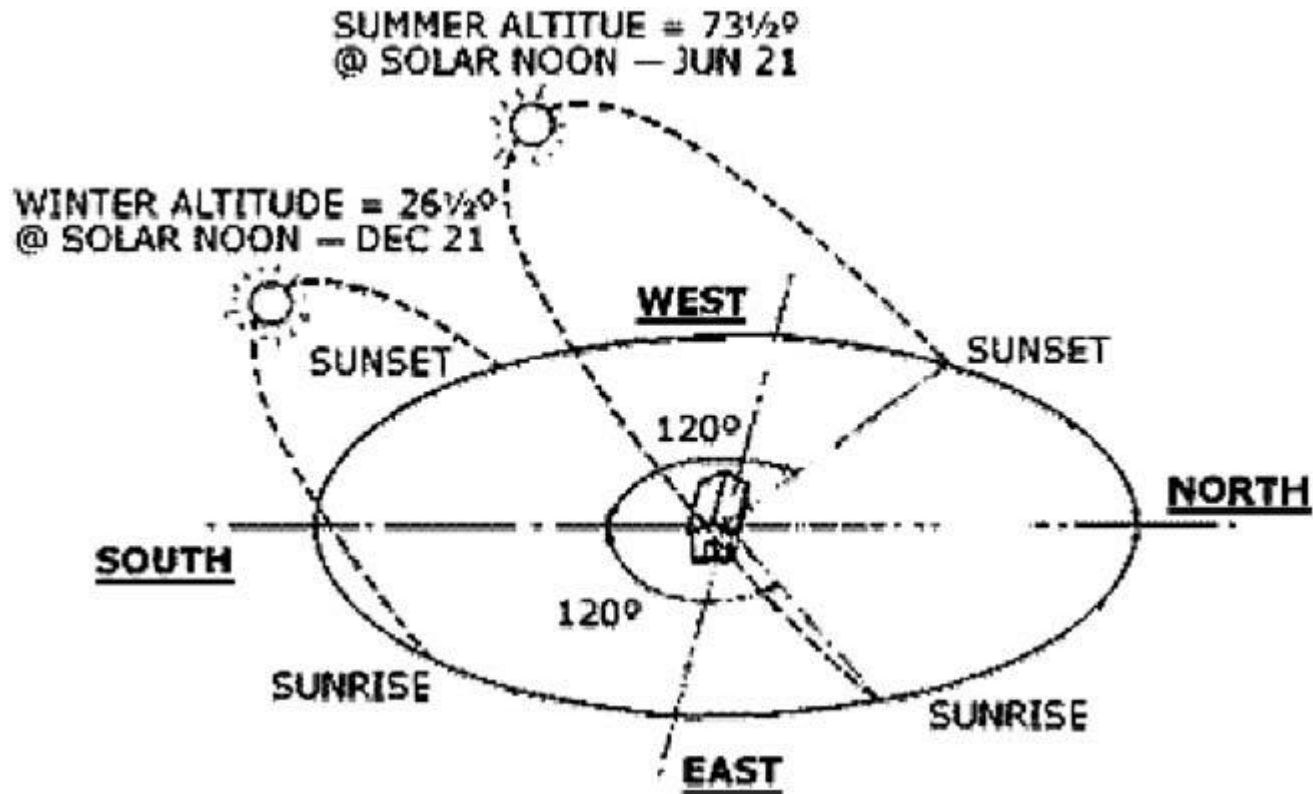
Photo: Chris Lent, NCAT

Sighting

- Flat topography
- Control rain water
 - Swales and Drainage
- Easy access
- Be aware of permitting and legal considerations
- Ensure there is no shading



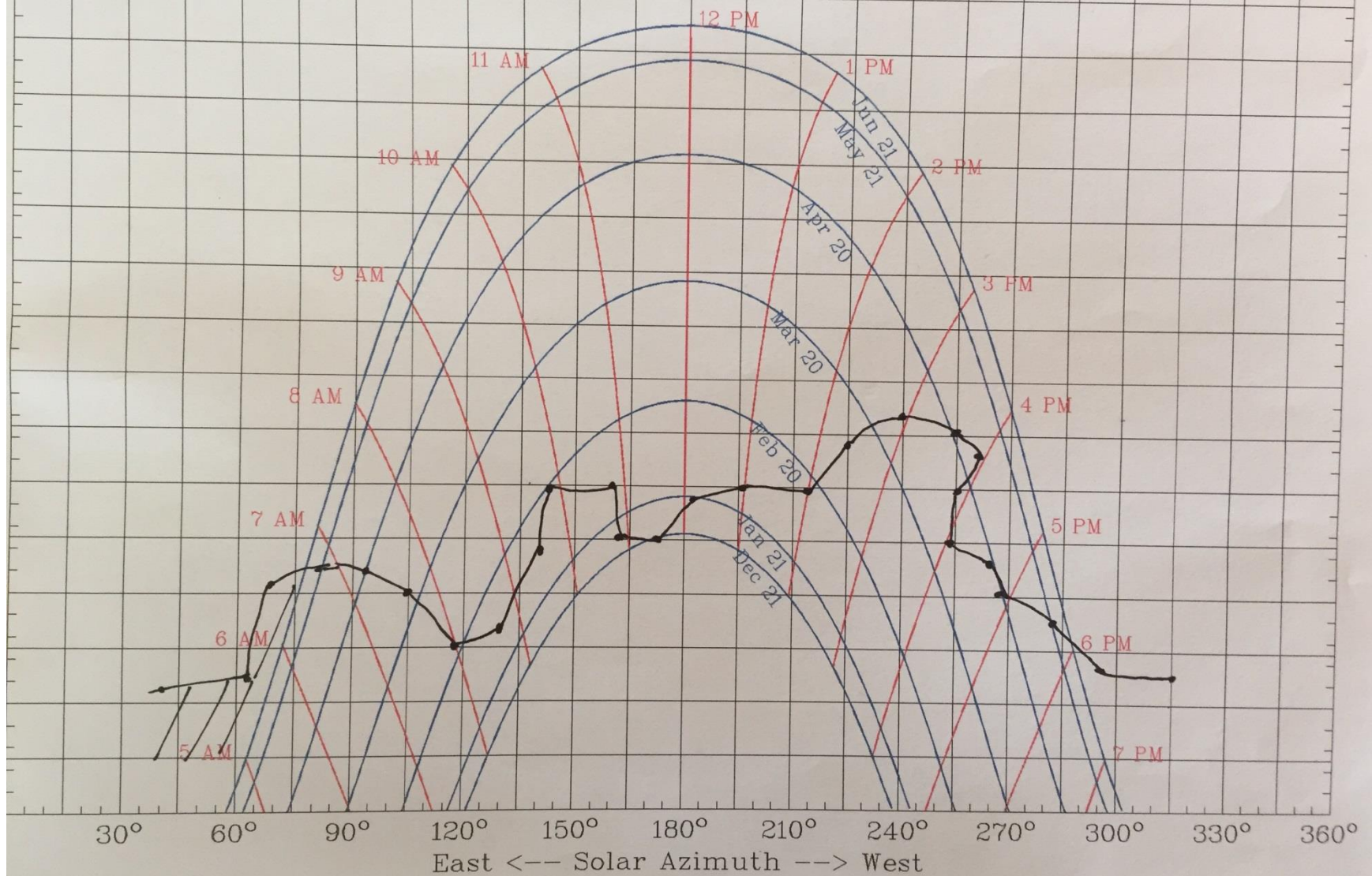
Sighting



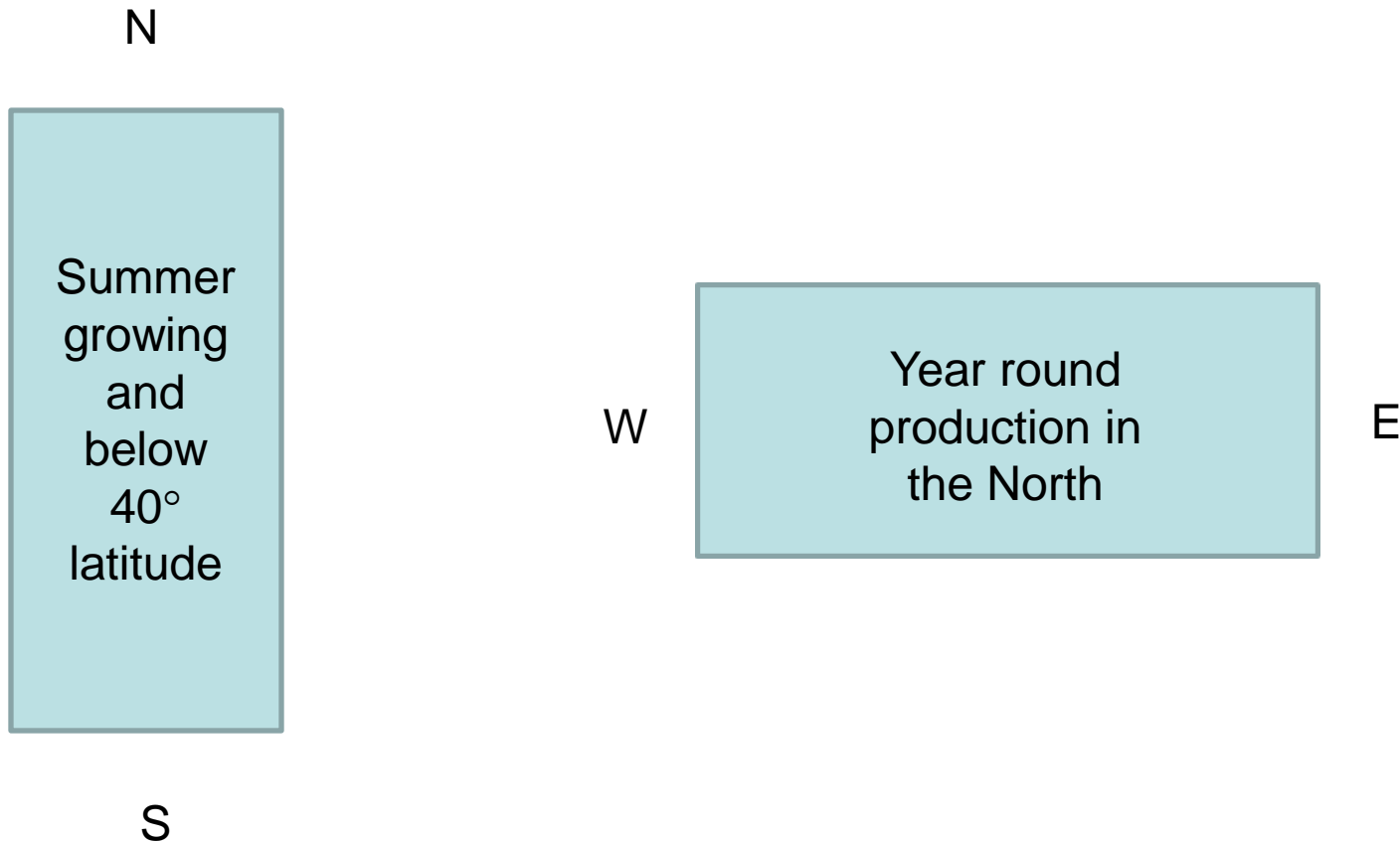
Source: Barbara Bellows. 2008. *Solar Greenhouses*. ATTRA National Sustainable Agriculture Information Service



Sponsor: D1 A
Lat: 41; Long: -76
(Solar) time zone: -5



Orientation



Production Systems

- Table top vegetable seedling or potted ornamentals
- In ground vegetable or cut flowers
- Table top container or bagged medium vegetables
- Floor grown container or bagged medium vegetables
- Hydroponics
- Aquaponics
- Aeroponics



Production Systems



Photo: Chris Lent, NCAT



Try Cell Size



Photo: Chris Lent, NCAT

- 72 count - greens
- 48 count – brassicas
- 32 count – cucurbits
- 2” to 4” Soil Blocks – tomato, eggplant, and peppers
- Organic production
- Hand watering
- Airflow

Potted and Bedding Plants



Photo: Andy Pressman, NCAT

Floor Grown



Ponics

- Hydroponics
- Aquaponics
- Aeroponics

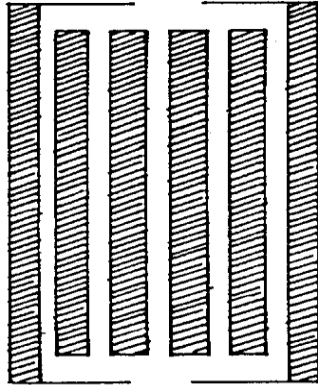


Photo: City Roots Farm, NC

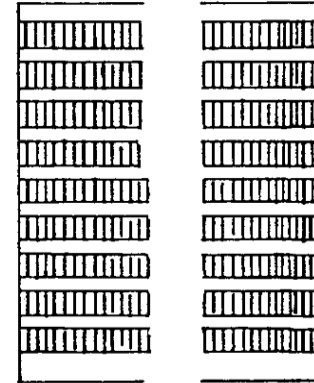


Interior Layout

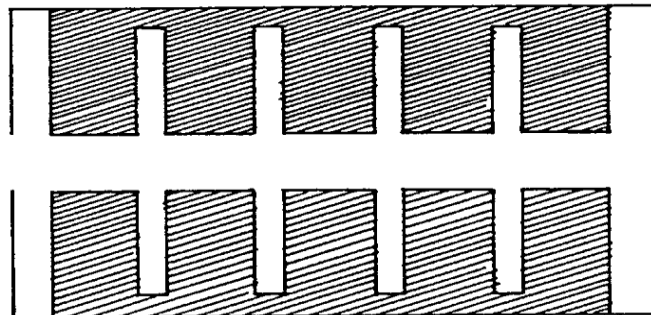
**Lengthwise Benching
(Longitudinal)**



**Crosswise Benching
(Island)**



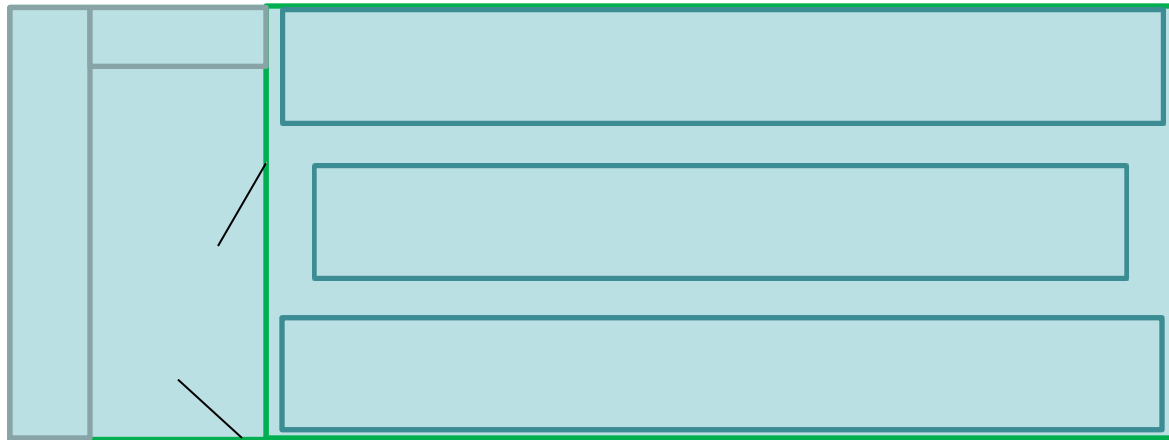
Peninsular Benching



DeFacio, Pickerel, and Rhyne. Greenhouse
Operation and Management. Instructional
Materials Laboratory.
University of Missouri-Columbia. 2002



Headhouse



Headhouse



Photo: Chris Lent, NCAT



Watering Systems

- Hand
- Drip Tube
- Flooded tables
- Mat Sub-irrigation
- Perimeter Irrigation



Photo: Andy Pressman, NCAT

Heating Systems

- Unit heaters
- Central heaters
- Emergency generators
- Electric



modine.com



Heat Distribution

- Forced hot air
- Radiant
 - Infrared
 - Hydronic
- Steam



Photo: Andy Pressman, NCAT

Hydronic Radiant Heat

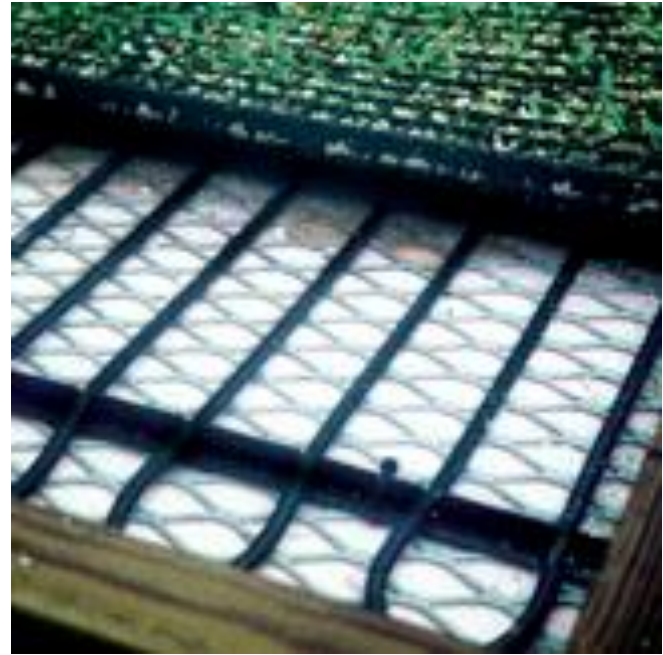


Photo: deltatsolutions.com

Alternative Heating Sources

- Wood pellets
- Biogas
- Biodiesel
- Geothermal
- Compost
 - Active
 - Hotbed
- Solar Thermal



Katherine Brooks: Misty Morning Herbs & More

<http://smallfarms.cornell.edu/2012/10/01/compost-power/>





extension.psu.edu/business/startfarming/vegetables/articles/two-designs-for-low-cost-hot-beds-for-small-scale-transplant-production



Photo courtesy: Dickenson College Student Farm



Passive Solar Greenhouse



Photo: University of Missouri Extension

- Uneven span
- 2-1-1 ratio
- Latitude determines slope
- East-West axis
- 2.5 gallons per square foot of glazing

people.umass.edu/~caffery/greenhouse



Ventilation and Cooling

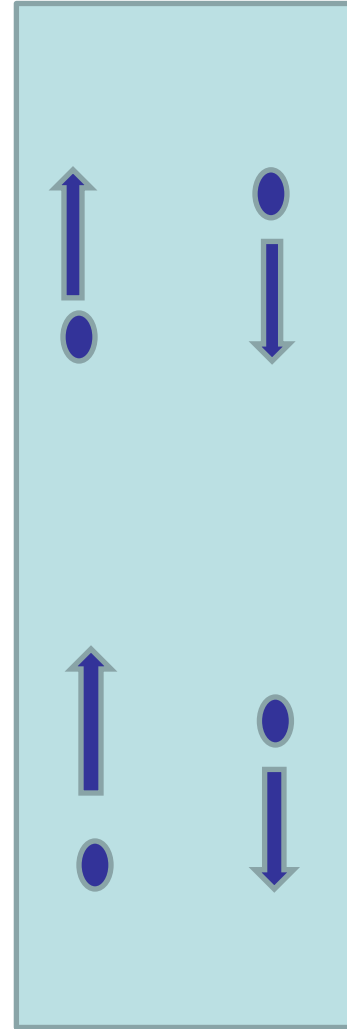
- Fans and louvers
 - 1 air exchange per minute
 - $\frac{1}{4}$ of that in winter
- Evaporative Cooling
 - Fan and Pad
 - Mist



Photo: Chris Lent, NCAT

Horizontal Airflow Fans (HAF)

- Even out temperatures
- Prevent foliar disease
- 50 to 100 ft./minute
- $\text{cfm} = \text{area} \times 2$
- 10 to 15 ft. from end wall
- 50 ft. apart



Glazing

Type	R-value	Cost/sq. ft.
Polyethylene - single	.87	\$.14
- double	1.7	\$.28
Polyethylene - ridged	2.5	\$2.00
Polycarbonate - double	1.6	\$1.25
- triple	2	\$1.60
Acrylic - double	1.8	\$3 - 4
Glass - double	2	\$6 - 8





Photo: site.outdora.com



Photo: Chris Lent, NCAT

Energy Efficiency

- Efficient glazing
 - Double up
 - IR inhibitor
- Insulation
- Air seal
- Efficient use of space
- Equipment maintenance
- Thermal Curtains (20% to 50%)
- Management
 - Delay starting in spring (germination chamber)
 - Lower nighttime temperatures



4 stage controller \approx \$500

Germination Chamber



farmhack.org/tools/sweet-box-germination-chamber-v20



Disease Control

- Manage humidity
 - Ventilation and spacing
- Irrigation control
 - Keep foliage dry
 - Infrequent watering
- Sanitation
 - Remove debris and weeds
 - Clean work areas
- Monitor



Disease Management

- Variety Selection
- Cultural Control
 - Crop rotation
 - Drip irrigation
 - Sanitation
 - Seed heat treatment
 - Ventilation
 - Plant spacing
- Biological Controls and Non Synthetic Fungicides



Common Greenhouse Insect pests



Photo courtesy of Central Science Laboratory.
Harpenden Archive, Bugwood.org

- White flies
- Spider Mites
- Aphids
- Thrips



Photo by Whitney Cranshaw, Colorado State
University, Bugwood.org

Insect Management

- Start with healthy soil and manage nutrients
- Encourage beneficials
- Don't use synthetic or non specific pesticides
- Prevent entry through screening
- Scout and monitor
- Trap crops
- Introduce beneficials/ insectary crops



Bio control resources

www.attra.ncat.org

biorational database

ATTRA publications

Greenhouse IPM:

Sustainable Aphid Control

Sustainable Thrips Control

Sustainable Whitefly Control

BioLogic

Lady bugs and nematodes

<http://www.biologicco.com>

IPM Labs Inc.

<http://www.ipmlabs.com/>

Web Resources

- extension.psu.edu/business/startfarming/vegetables/articles/two-designs-for-low-cost-hot-beds-for-small-scale-transplant-production
- people.umass.edu/~caffery/greenhouse
- farmhack.org/tools/sweet-box-germination-chamber-v20
- ag.umass.edu/greenhouse-floriculture/fact-sheets/greenhouse-management
- greenhousepestguide.umass.edu/ and greenhousediseaseguide.umass.edu/



Greenhouse Supplies

- FarmTek:
www.farmtek.com
- Growers Supply:
www.growerssupply.com
- Rimol:
www.rimolgreenhouses.com
- Four Season Tools:
www.smallfarmtools.com
- Delta T Solutions:
www.deltatsolutions.com



Thank You

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ATTRA
SUSTAINABLE AGRICULTURE

Helping people by championing small-scale, local, and sustainable solutions to reduce poverty, promote healthy communities, and protect natural resources.